Analysis of Modernization Scenarios for SEPTA Route 34

MAY 2016

DELAWARE VALLEY
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REGIONAL
PLANNING COMMISSION

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Executive Summary

The Southeastern Pennsylvania Transportation Authority (SEPTA) is engaged in a multiyear effort to modernize its roughly 35-year-old Kawasaki trolley fleet with new wheelchair-accessible trolleys and stops, potentially supplemented with other operational changes. The purpose of this study was to use VISSIM microsimulation software to test the travel time and delay outcomes of various trolley modernization scenarios for the street-running portions of SEPTA Route 34. The microsimulation analysis was built on a prior Delaware Valley Regional Planning Commission (DVRPC) *Transit First Analysis of Route 34* (pub. 09040, March 2010), updated to reflect new 2014 baseline traffic and transit conditions.

This effort also included an initial analysis of some of the modernization elements under consideration, drawing on SEPTA data and industry peer experience, as well as sketch projections of likely wheelchair boarding rates for accessible trolleys based on SEPTA's experience with other accessible routes. Table ES1 summarizes the scenarios that were simulated, as well as the end-to-end trolley travel time projections that resulted. More explanation of these scenarios and findings can be found in Chapter 2.

Table ES1: Summary of Simulated Route 34 Time Savings by Scenario and Direction

	Scenario (AM Peak)	Eastbound* surface travel time change from base	Westbound surface travel time change from base
BASE	**Existing Kawasaki fleet**	N/A	N/A
Vehicle option A: Front-door boarding with operator-assist ADA			
A1	**New vehicles**	+0.4%	+1.2%
A2	**New vehicles + TSP**	–1.9%	–8.0%
A3	**New vehicles + TSP + Stop consolidation**	–9.8%	–11.6%
Vehicle option B: 2-door boarding/low-friction fare payment, automated ADA ramp			
B1	**New vehicles**	–12.9%	–7.8%
B2	**New vehicles + TSP**	–15.1%	–12.8%
B3	**New vehicles + TSP + Stop consolidation**	–19.8%	–14.8%

*** Peak direction for the AM peak (higher trolley passenger boardings and auto traffic volumes).**

Source: DVRPC, 2015

In general, the results of the simulation revealed that higher levels of intervention resulted in higher levels of projected cumulative travel time benefit. Most notably:

- Projected time savings were significantly greater in simulations of vehicle option B than in simulations of vehicle option A. Projected time savings for scenario **B1** (lower-friction boarding, *without* transit signal priority [TSP] or stop consolidation) are comparable to those of scenario **A3** (higher-friction boarding *with* both TSP and stop consolidation).
- TSP and stop consolidation were found to be most impactful in combination (as in scenarios **A3** and **B3**), illuminating their complementary relationship.

CHAPTER 1:

Background and Initial Analysis

Introduction

SEPTA is engaged in a multiyear effort to modernize its roughly 35-year-old Kawasaki trolley fleet with new wheelchair-accessible trolleys and stops, potentially supplemented with other operational changes. The purpose of this study was to use VISSIM microsimulation software to test the travel time and delay outcomes of various modernization scenarios for SEPTA Route 34—specifically, the surface portion of the route during the AM peak period. The microsimulation analysis was built on a prior DVRPC *Transit First Analysis of Route 34* (pub. 09040, March 2010), updated to reflect new 2014 baseline traffic and transit conditions. This effort also included an initial analysis of some of the modernization elements under consideration, drawing on SEPTA data and industry peer experience, as well as sketch projections of likely wheelchair boarding rates for accessible trolleys based on SEPTA's experience with other accessible routes.

Prior DVRPC Analysis of Route 34

This 2010 project used a microsimulation model of the surface portion of Route 34—along Baltimore Avenue from the 40th Street trolley portal to the 61st Street loop (see Figure 1)—to test the travel time impacts of various combinations of stop consolidation and TSP.

The analysis investigated three stop consolidation scenarios: "low" (removing four of 22 stops), "medium" (removing seven of 22 stops), and "high" (removing 11 of 22 stops.) The analysis found that the "medium" stop consolidation scenario with TSP would provide the best overall improvement by balancing vehicle and passenger time savings. While the 2010 analysis considered important factors in developing stop consolidation scenarios, such as ridership and transfer opportunities, it did not analyze the construction feasibility of Americans with Disabilities Act (ADA)-compliant stations. As of this printing, SEPTA has not determined whether it will pursue stop consolidation on trolley routes, nor has it identified candidate stops for consolidation—a complex policy consideration that will involve issues above and beyond travel time impacts.

Like the present study, the 2010 analysis used Route 34—a relatively short route with a simple surface alignment and regular stop and signal spacing—as a laboratory to explore operating changes that could be applied to other SEPTA trolley routes.

Figure 1: Route 34 Context Map

Source: DVRPC, 2016

Route 34 in Comparison to Other Subway-Surface Routes

Since this simulation analysis of Route 34 is intended to also be instructive for other trolley routes (particularly other subway-surface trolley routes), it is useful to understand how Route 34's operating conditions align with its peers. Table 1 presents a comparison across several basic performance metrics.

Table 1: Select Comparative Metrics for Subway-Surface Trolley Routes

Route	34		10		11		13		36	
Stops	#	%	#	%	#	%	#	%	#	%
Distance between stops (feet)										
1-399	2	*9%*	5	*16%*	6	*15%*	4	*10%*	4	*10%*
400-499	2	*9%*	7	*22%*	9	*23%*	6	*15%*	10	*25%*
500-599	13	*59%*	5	*16%*	15	*38%*	21	*54%*	13	*33%*
600-699	2	*9%*	1	*3%*	5	*3%*	5	*13%*	6	*15%*
700-799	1	*5%*	5	*16%*	3	*8%*	1	*3%*	4	*10%*
800+	2	*9%*	9	*28%*	2	*5%*	2	*5%*	3	*8%*
Total stops	22		32		40		39		40	
Median stop spacing (feet)	523		561		520		544		529	
Average stop spacing (feet)	541		657		546		573		558	
Alignment										
Surface route length (miles)	2.6		4.3		4.3		4.4		4.7	
Total route length (miles)	4.8		5.9		6.7		6.8		7	
Surface route % of total	54%		72%		65%		64%		68%	
AM Peak Frequency										
Smallest headway (minutes)	3		5		6		4		4	
Avg. daily boards by stop (2012)	Eastbound	Westbound	Eastbound	Westbound	Eastbound	Westbound	Eastbound	Westbound	Eastbound	Westbound
	181	41	132	44	116	59	124	30	134	47

Source: SEPTA, 2012; DVRPC, 2015

Generally speaking, the operating context and service patterns of each route are fairly similar, suggesting that the findings of this analysis are broadly adaptable. Route 34 is the shortest of the subway-surface trolley routes, both overall and in terms of its surface running portion. Its stop spacing is similar to other routes but with stops being spaced more consistently.

Other trolley routes are both longer and have lower average peak direction ridership per stop. This suggests that Route 34 may have more potential for *dwell time savings* (achieved through fare payment and boarding changes), whereas other routes may have more potential for *travel time* savings between stops (through strategies like stop consolidation and transit signal prioritization).

Route 34 is also similar to other subway-surface trolley routes in the sense that stations within the tunnel are its primary ridership generators. The trolley tunnel extends between the 40^{th} Street Portal (in the west) and 13^{th} Street Station (in the east). The nine tunnel stations serve Center City and University City, which together represent the principal employment hub for the entire Greater Philadelphia region. Three of those stations offer free transfers to either the Market-Frankford Line or Broad Street Line.

As a result, over 90% of AM peak direction (eastbound) trolley passengers alight at a tunnel station, and over 90% of PM peak direction (westbound) trolley passengers board at a tunnel station. This enables low-friction fare payment (discussed at length below) while minimizing fare evasion, as tunnel stations can be gated, with fares collected upon either entry or exit from stations.

New Element 1: Low-Friction Fare Payment with Multidoor Boarding

One element that differentiates many modern streetcar or in-street light rail transit (LRT) operations from earlier systems that preceded the ADA—such as SEPTA's subway-surface trolleys—is an effort to reduce the "friction" of passenger boarding and alighting through a package of vehicle design, stop design, and fare payment changes. These strategies typically include:

- multi-door boarding and alighting;
- low-friction fare payment (either off-board fare collection or fare collection at multiple doors);
- accessible boarding (enabled through low-floor vehicles, raised curbs at stops, and wheelchair ramps); and
- limited operator interaction for fare payment and for wheelchair boardings or ADA ramp deployment.

When combined, these strategies can enable efficient wheelchair access while reducing boarding and alighting times for all passengers.

This project began with an exploratory sketch analysis of how these strategies could impact SEPTA trolley dwell times and running times, both to inform SEPTA's initial procurement evaluations, and to develop factors that would be used in the updated microsimulation scenarios.

Industry-standard default values[1] for per-boarding-passenger service time range from 3 to 5 seconds for SEPTA's token (3 seconds), cash (4.5 seconds), and magnetic stripe (5 seconds) fare mix. In comparison, per-boarding-passenger service times of 1.75 seconds are suggested for "no fare payment," or fare prepayment. Standard per-passenger rear-door alighting times are also 1.75 seconds. The same guidance also indicates that per-passenger boarding and alighting service times are reduced by 40 percent and 25 percent, respectively, with the addition of a second entry/exit point.[2] Adding additional entrance/exit channels would save still more time but with diminishing returns. It bears noting that these are rough rules of thumb that can vary quite a bit based on local conditions, vehicle/payment details, and they do not consider the impact of step-up versus level or near-level boarding. However, they combine to yield a reasonable estimate of service times for purposes of comparison.

Averaging boarding and alighting values under existing SEPTA trolley operations yields an overall dwell time estimate of 2.9 seconds per boarding or alighting passenger. Whereas averaging boarding and alighting values under a modernization scenario yields an overall dwell time estimate of 1.2 seconds per boarding or alighting passenger—an overall reduction of 59 percent.[3]

This is an initial sketch exploration of running time implications. The full analysis is detailed in Appendix A.

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[1] Transit Capacity and Quality of Service Manual (TCQSM), 3rd Edition, 2013 (p. 6-7).
[2] Transit Capacity and Quality of Service Manual (TCQSM), 3rd Edition, 2013 (p. 6-68).
[3] For a peer 'ground truth,' this compares with a reduction in per-passenger dwell times from 3.52s to 1.12s (68%) experienced by MTA/New York City Transit for the Bx41 Select Bus Service (SBS) project, following equivalent fare payment and boarding/alighting changes.

New Element 2: ADA Accessibility and Ramp Deployment

Another element shared by modern street-running rail services is accessibility itself. Access for people in wheelchairs is a considerable improvement with enormous quality of life benefits for those users (and often for other passengers with mobility impairments, as well as those with strollers or luggage). It can also impact dwell times substantially, depending on vehicle and stop design.

As a result, the second key task of this project was to estimate the frequency of wheelchair boardings (ramp deployments) based on SEPTA paratransit demand and wheelchair boarding rates for accessible buses, as well as per-ramp-deployment dwell times, based on a review of peer system information.

DVRPC staff used two approaches to estimate an ADA ramp-deployment rate for accessible trolleys:

- Method A examined current ADA ramp deployment rates on a sample of buses, as well as the Route 15 trolley, which operate a portion of their service in West Philadelphia near trolley routes proposed for modernization.
- Method B developed daily trip-rate estimates for the registrants in SEPTA's Customized Community Transportation (CCT) program who are eligible for ADA Paratransit demand-response service, and live within a quarter or eighth of a mile from West Philadelphia trolley lines. Registrants in these programs are more likely to use ADA ramps when riding fixed-route service.

Based on the findings of both approaches (detailed in Appendix B), DVRPC developed a ramp deployment rate of 6 percent for use in this project's simulations (e.g., 6 percent of trolley runs will require ramp deployments). The 6 percent rate is slightly higher than existing ADA boarding rates explored in methods A and B, which helps account for any latent demand that may manifest upon the introduction of modern trolleys.

To estimate per-deployment dwell times, DVRPC reviewed a series of YouTube recordings that show a customer in a wheelchair boarding and alighting via an ADA ramp from various peer light rail and streetcar systems, as well as *Transit Capacity and Quality of Service Manual* (TCQSM) guidance. Based on this review, the project team estimates that a passenger boarding using an ADA ramp will require 70 seconds for an operator-assisted ramp deployment scenario and 25 seconds for an automated deployment scenario. Alightings were estimated at 60 seconds for operator-assisted deployment and 20 seconds for automated deployment, respectively.

The full analysis, including all peer observation data, is detailed in Appendix B.

CHAPTER 2:

Simulation of Modernization Scenarios

Overview of Approach and Tools

Microsimulation modeling was used to evaluate the impacts of various operational scenarios on the performance of a new vehicle fleet serving the Baltimore Avenue trolley corridor (Route 34). With the replacement of SEPTA's trolley fleet by modern light rail vehicles, ADA compliance will become mandatory. The simulation scenarios were used to evaluate the effects of ADA boardings and several conceptual strategies that could mitigate or offset the additional time needed to accommodate ADA boardings.

As noted earlier, deploying a ramp to allow disabled persons to board a transit vehicle must be factored into boarding time estimates. Specifically, the method of ramp deployment determines boarding time estimates. Ramp deployment methods vary greatly; ramps may be actuated by the driver or called by a passenger. If the ramp is driver operated, the degree of driver involvement/control required also varies significantly. The fastest option on this spectrum, short of level boarding[4], is a passenger-called automated ramp; the slowest is a driver-operated lift with manual controls, such as that used on SEPTA Route 15 trolleys today.

In order to maximize dwell efficiency in the context of the ramp deployments predicted, three strategies were tested. The first was low-friction boarding and fare payment: this consisted of modeling two-channel boarding with either prepaid ticketing, onboard payment at two doors, or payment upon alighting in a tunnel station. Low-friction boarding/fare payment stands in contrast to the current model for boarding SEPTA trolleys, which requires that all passengers board through a single door and pay their fare at a single point during boarding.

Low-friction boarding also assumes a passenger-called, automated ramp, while the basic fleet replacement scenario envisions single-channel boarding and ramp deployment that requires driver assistance. It is important to note here that this exercise does not endorse any particular means of accomplishing low-friction boarding; it merely explores the outcomes if an appropriate strategy were developed and adopted.

Two additional scenarios were built from each of the low-friction and single-channel boarding base alternatives. These additional simulations added, sequentially, TSP—a system that extends green time at intersection signals to give transit vehicles a larger window to pass through, or allows queues of cars ahead of a transit vehicle to clear—and stop consolidation, in which the service pattern is changed to remove some stops, with passenger demand shifting to the remaining stops. This reduces time associated with trolley acceleration and deceleration and eliminates the need for the vehicle to stop for passengers at some intersections.

Stop consolidation and TSP function as complementary interventions. If a trolley must stop at an intersection for passengers, it cannot take full advantage of an extended green, as the vehicle will often be stopped for passengers during that green light phase. On the other hand, if a trolley *does not* need to stop for passengers at

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[4] Fully level boarding—typically, 13- to 14-inch-high platforms that match the floor height of trolley vehicles—is the ideal boarding method in terms of accessibility and dwell time efficiency. Yet, level boarding is most likely impracticable on on-street portions of SEPTA trolley routes for several reasons.

Fully level platforms are more difficult to integrate into the streetscape due to longer ramp slopes, drainage issues, limited street and sidewalk space, and utility conflicts. Level boarding also requires a less-than-one-inch gap between the platform edge and vehicle door, pushing the platform edge further into the shared travel lane.

Finally, fully level platforms are largely incompatible with bus floors, which often feature wheelchair ramps that cannot deploy onto platforms higher than 8 to 10 inches. This limits flexibility for shared stops and temporary bus substitution for trolley service.

an intersection, it is more likely to clear the intersection during its extended green phase. This is particularly relevant on corridors such as Baltimore Avenue, with trolley stops at every signalized intersection.

The stop consolidation scenarios modeled the corridor with seven of 22 stops removed. This was the “medium” level of consolidation developed and recommended in the 2010 study, with route-level running time impacts that would be illustrative of other consolidation outcomes that vary in their details. In this scenario, passengers boarding at the eliminated stops are reallocated, primarily downstream, to maintain total demand. It is assumed, for purposes of the simulation, that all current passengers are willing to walk the additional block to continue to access the trolley, and that no new passenger demand is induced by faster travel times—in short, that passenger demand is fixed.

Scenario Summary

This project had the capacity to test six trolley modernization operating scenarios for Route 34 during the AM peak period. These scenarios were nested (i.e., they build on one another so that incremental/cumulative impacts can be isolated), and are as follows:

VEHICLE OPTION A: FRONT-DOOR BOARDING WITH OPERATOR-ASSISTED RAMP DEPLOYMENT

Models the Siemens S70 Ultra Short Light Rail Vehicle ["S70"][5] design, but a customized version restricting passenger flow to front-door boarding for street-level stops. The operator would be required to park the vehicle and leave their chair to assist projected volumes of wheelchair users at a mid/rear-vehicle low-floor accessible boarding door every time a wheelchair passenger needs to board and alight the vehicle.

SCENARIO A1: Vehicle replacement

Replacement of baseline Kawasaki fleet with the vehicle type described above, operating with the ADA/wheelchair-boarding rates noted in Chapter 1.

SCENARIO A2: Scenario A1 + TSP

Adds TSP (standard optical treatment; 10-second green phase extensions).

SCENARIO A3: Scenario A2 + Stop consolidation

Adds stop consolidation (the recommended medium-level consolidation scenario from the 2010 analysis).

VEHICLE OPTION B: LOW-FRICTION BOARDING WITH AUTOMATED RAMP DEPLOYMENT

Models the Siemens S70 Ultra Short Light Rail Vehicle ["S70"] design with multidoor (two-channel) near-level boarding for street-level stops with curb extensions. Operator assistance for ADA ramp deployments is negligible since ramp deployment is automated, and ADA regulations do not require operators to strap in wheelchair passengers for rail service.

SCENARIO B1: Vehicle replacement

Replacement of baseline Kawasaki fleet with the vehicle type described above, operating with the ADA/wheelchair-boarding rates noted in Chapter 1.

SCENARIO B2: Scenario B1 + TSP

Adds TSP (standard optical treatment; 10-second green phase extensions).

SCENARIO B3: Scenario B2 + Stop consolidation

Adds stop consolidation (the recommended medium-level consolidation scenario from the 2010 analysis).

What is VISSIM/Why Microsimulation?

Traffic microsimulation is used to assess the effect of various changes to the transportation system at the finest level of detail. Microsimulation works by modeling the actions of every vehicle on the road at a sub-second basis. The main component is a car-following model which predicts whether a driver will speed up, slow down, or maintain speed. Simulated drivers make these decisions based on their desired speed and their environment,

[5] This vehicle was selected for simulation of a contemporary accessible fleet since it has been a common choice in recent North American fleet procurements, and there is robust industry data as a result. The S70's operational characteristics are in line with industry standards. Thus, the simulated results are assumed to be broadly applicable to other vehicle models.

including the distance and speed of the vehicle in front of them, roadway geometry, desired route, and the status of upcoming traffic signals. There are also models for simulating passenger boarding and alighting on transit vehicles. Traffic microsimulation is a powerful predictive tool because both vehicle physics and driver behavior are modeled at an elementary level. The VISSIM microsimulation software package by PTV was used for this project.

The use of a simulation model further allows for an accounting of the interactions between interventions (i.e., the combined effects of multiple interventions together may be smaller or larger than the sum of those same interventions in isolation). By modeling traveler and vehicle behavior, a properly calibrated simulation model can better estimate overlapping impacts than a simpler cumulative spreadsheet exercise. Microsimulation also allows for the particulars of a corridor or area to enter into analyses, rather than relying on a set of spreadsheet calculations that are largely agnostic as to the geographic and operational specifics of a given study area.

For this study, microsimulation allows us to estimate the combined effect of TSP and stop consolidation. The model also accounts for the shared right-of-way (ROW) with automobile traffic and the acceleration/braking specifications of the rail vehicles modeled. These operational characteristics in turn create conflict and delay in the simulation, which can be measured.

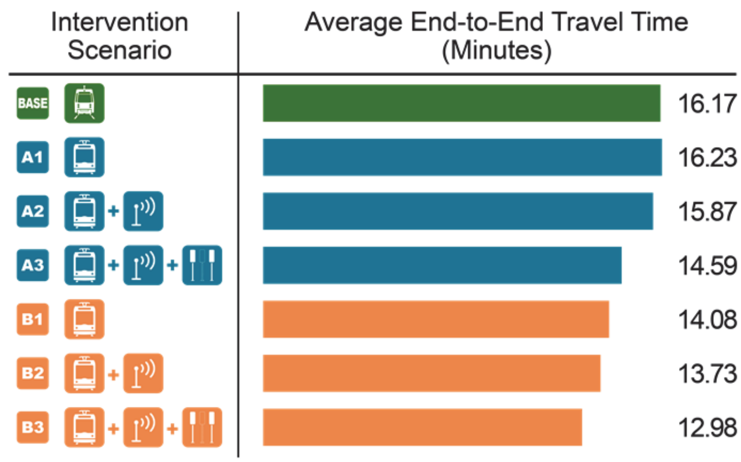
Results of Scenario Testing

As Figures 2 and 3 indicate, we find that there is a cumulative benefit to the simulated interventions in the peak direction for the AM peak period (eastbound). We also see that the relative magnitude of benefits from TSP combined with stop consolidation (scenarios **A3** and **B3**) decrease under the low-friction boarding scenario. This diminishing return is explained by the low-friction boarding vehicle platform, which reduces sufficient existing boarding-related dwell time, and effectively limits the available additional time savings that are achievable under existing passenger demand.

Vehicle Option A (scenario **A1**), without TSP or stop consolidation, is slower than the no-build scenario due to the failure to address the bottleneck effect of single-channel boarding coupled with the additional time lost to operator-assisted deployment of the ADA ramp.

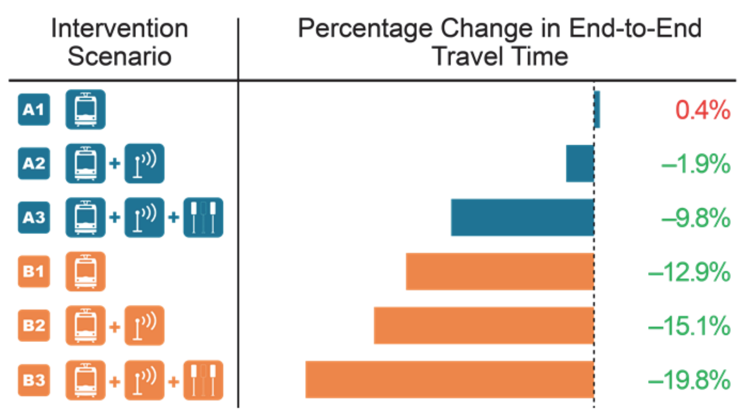
This is a predictable and realistic outcome, given that non-ADA boardings remain constant, as does the approximate time to

Figure 2: Average Route 34 Eastbound Travel Time



Source: DVRPC, 2015

Figure 3: Percentage Change in Route 34 Eastbound Travel Time



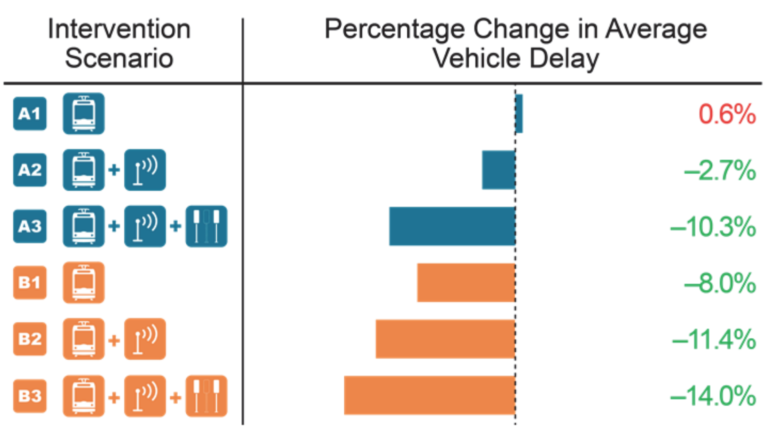
Source: DVRPC, 2015

board per passenger, while an additional 70 seconds is added to 6 percent of vehicle journeys for the ADA boardings. It should be noted that end-to-end times are averages for all trolleys, and any given run that requires ramp deployment will experience a potentially significant delay, with commensurate disruption for other traffic on the corridor. It should also be noted that additional ramp deployment time for alighting is not considered, as approximately 90 percent of alights during the AM peak simulation period occur in the tunnel, outside of the simulated route segment.

The largest savings in end-to-end time come from low-friction boarding and stop consolidation, as seen in the marked drops between **A1** and **B1** (13.3 percent); **A2** and **A3** (7.9 percent); and **B2** and **B3** (4.7 percent). The modest gains from TSP alone are the result of trolleys continuing to stop at almost every block under scenarios **A2** and **B2**.

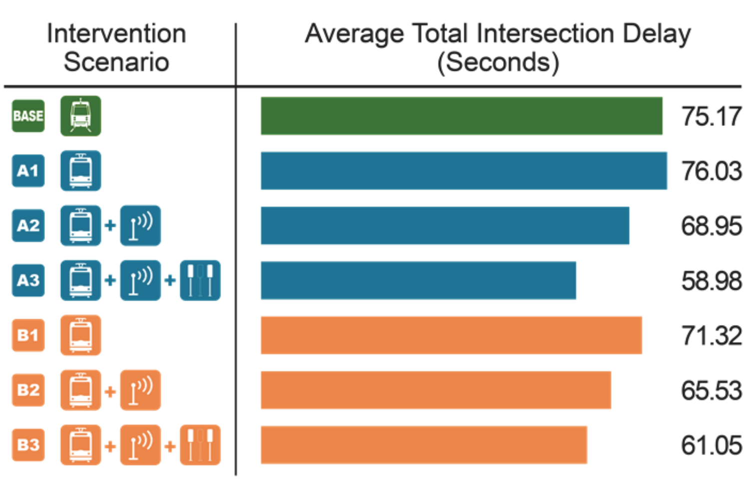
Sharp drops in end-to-end times under the stop consolidation scenarios (**A3** and **B3**) are attributed to the synergistic effects of TSP and stop consolidation. By removing low-ridership stops from the line, consolidation allows the cycle extension created by TSP to more frequently marshal the trolley through a given intersection. In the absence of consolidation, the TSP will more often serve to extend a signal cycle long enough to clear the queue ahead of the trolley, but due to the continued need to stop for boarding or alighting, the time savings achieved will remain limited.

Figure 4: Percentage Change in Average Delay (All Vehicles on Baltimore Avenue)



Source: DVRPC, 2015

Figure 5: Average Total Trolley Intersection Delay (Seconds)



Source: DVRPC, 2015

From scenario to scenario there is a noticeable degree of improvement, not just for the end-to-end running times of the trolleys, but also for the delay experienced by auto traffic on the corridor. Figure 4 shows the percentage change in delay for all vehicles using the corridor under the build scenarios. Delay refers to the average amount of time that it takes a vehicle to pass through the study corridor beyond what would be experienced in a low-traffic condition. There is a clear benefit to drivers from improving trolley operations, as trolleys effectively become moving bottlenecks on a one-lane-by-direction facility like Baltimore Avenue.

Figure 5 shows the average total intersection delay for the simulation period by alternative for trolleys. As previously noted, the bottleneck created by trolleys means that reducing intersection delay for trolleys also improves travel times for drivers, hence the similarity seen in Figures 5 and (the inverse of) 4.

Additional details on the development, calibrations, and findings of the simulation analysis can be found in Appendix C.

CHAPTER 3:

Conclusion

This project used the VISSIM microsimulation platform to test the impacts of various trolley modernization scenarios on travel times (and related performance measures) for Route 34 trolleys. Table 2 summarizes the projected travel time savings in comparison to the base case across each of the simulated scenarios.

Table 2: Summary of Simulated Route 34 Time Savings by Scenario and Direction

	Scenario (AM Peak)	Eastbound* surface travel time change from base	Westbound surface travel time change from base
BASE	**Existing Kawasaki fleet**	N/A	N/A
Vehicle option A: Front-door boarding with operator-assist ADA			
A1	**New vehicles**	**+0.4%**	**+1.2%**
A2	**New vehicles + TSP**	**–1.9%**	**–8.0%**
A3	**New vehicles + TSP + Stop consolidation**	**–9.8%**	**–11.6%**
Vehicle option B: 2-door boarding/low-friction fare payment, automated ADA ramp			
B1	**New vehicles**	**–12.9%**	**–7.8%**
B2	**New vehicles + TSP**	**–15.1%**	**–12.8%**
B3	**New vehicles + TSP + Stop consolidation**	**–19.8%**	**–14.8%**

*** Peak direction for the AM peak (higher trolley passenger boardings and auto traffic volumes).**

Source: DVRPC, 2015

In general, higher levels of intervention resulted in higher levels of projected cumulative travel time benefit. Notably, the projected time savings for scenario **B1** are comparable to those of scenario **A3**. In other words, **a vehicle with higher-friction boarding and fare payment would need to be supplemented with both TSP and stop consolidation to achieve comparable travel times to a vehicle with lower-friction boarding and fare payment.**

It also bears noting that the projected travel time savings under scenario **B1** in the peak direction are similar to the 15 percent travel time savings that were initially estimated at a sketch level for a vehicle scenario that was similar but did not include wheelchair boardings (see Appendix A). This is a useful crosscheck that reinforces the usefulness of transparent, sketch-level estimates for future travel time assessments.

Appendix A

August 2014 memorandum on running time savings, as transmitted

DELAWARE VALLEY dvrpc REGIONAL PLANNING COMMISSION ··· memo

Date: August 11, 2014

To: E. Johanson, SEPTA

From: G. Krykewycz, DVRPC

Subject: Potential trolley surface running time savings from fare prepayment and multi-door boarding

PURPOSE

The question of whether SEPTA's modernized trolley fleet will have a traditional bus-style boarding and fare payment approach (front-door boarding, interior fare payment, operator interaction) or a modern streetcar-style approach (multi-door boarding, off-board fare payment with periodic inspection, no operator interaction) is foundational to SEPTA's procurement choice as well as the FY2015 DVRPC operations analysis and curbside design projects now underway.

Experiences with SEPTA's traditional trolley fare payment approach are well understood through decades of practice. The purpose of this memo is to prepare sketch-level estimates of travel time (trolley end-to-end running time) savings that could be achieved through a modernized, industry-standard fare payment approach.

ANALYSIS

1. DWELL TIME AVAILABLE TO BE SAVED

This analysis focuses on AM peak eastbound surface operations for the Route 34 trolley, although its findings should be broadly transferable to other City trolley routes which share many operating characteristics. Baseline travel times for Route 34's surface running alignment (61st Street to 40th Street; roughly 2.4 miles) are as follows:

- Morning peak scheduled Route 34 eastbound trip time: 18 minutes
- Typical morning peak eastbound drive times (from Google Maps, with traffic): 12.5 minutes

Thus, the upper bound potential for non-signals-related trolley running time savings is 5.5 minutes[1]. This 'total trolley time lost' is comprised of trolley vehicle attributes (slower acceleration and deceleration versus an automobile) and

[1] Note that this is not a true 'apples to apples' comparison, since cars cannot pass trolleys on Baltimore Avenue—so auto travel time is impacted by trolley travel time. Google's 'free flow' auto travel time estimate for this corridor is 9 minutes.

passenger-related dwell time (e.g., time that the trolley spends stopped where autos would not, unless waiting behind a trolley).

Trolley vehicle attributes

Electric trolley acceleration and deceleration rates are fairly competitive with those of a typical automobile (3.9 mph/s for a Kawasaki trolley versus 3.0 mph/s for a typical car); suggesting that vehicle attributes should be responsible for only a small portion of our estimated 5.5 minutes for trolley running time available to be saved.

Passenger-related dwell time

To conduct this analysis effectively, we needed to estimate the typical (average) passenger-related dwell time at SEPTA trolley stops. After reviewing the quality and sampling of available batches of recent Automatic Passenger Count (APC) data for all subway-surface trolley routes, SEPTA surface transportation staff provided the batch that best balanced a large sample size with clean data: Fall 2013 data for the Route 10 trolley. This data includes fields for every instance where a trolley stopped, when it began moving again, and whether there were any boardings or alightings during this time. Together, these fields allow us to calculate the trolley's average time stopped when there was passenger activity (e.g., at passenger stops), and compare it with the average time stopped for any reason *other than* passenger activity. Excluding subway and terminal stops, these figures for Route 10 from this dataset were 40.3 seconds and 17.8 seconds, respectively. Subtracting the latter from the former yields an average passenger-related dwell time per trolley stop of 22.5 seconds—exactly in line with industry default values of 15- and 30-seconds for minor and major non-downtown bus stops[2].

From the most recent Route 34 Ridecheck data available (Fall 2009), during the AM peak the typical Route 34 trolley has passenger activity at 17 of the 20 eastbound stops between 61st Street and the 40th Street portal. Multiplying our average dwell time per trolley stop (assumed to be transferable from Route 10) of 22.5 seconds by these 17 stops yields an estimate of 6.4 minutes in passenger-related dwell time for the typical Route 34 eastbound AM peak run (which would be 36% of running time). This exceeds our estimated available time to be saved of 5.5 minutes. However, as noted, that time estimate is complicated since auto travel times are limited by trolley travel times (so available time to be saved could be greater).

Conclusion

Taking into account vehicle attributes and our passenger-related dwell time estimates, for the purposes of this analysis, we will conservatively estimate that 5.0 minutes of Route 34's 18-minute running time (28%[3]) are associated with passenger activity, and could be impacted by boarding and fare payment changes.

[2] Transit Capacity and Quality of Service Manual (TCQSM), 3rd Edition, 2013 (p. 6-67).

[3] For a peer 'ground truth,' this compares with 29% calculated by MTA/New York City Transit as part of a baseline (pre-test) evaluation of their Select Bus Service (SBS) program.

2. DWELL TIME THAT WOULD BE SAVED

As noted in the introduction, there is an opportunity to save travel time through a combination of three interrelated strategies: low-floor boarding, which reduces passenger time spent 'stepping up'; fare prepayment, which reduces time spent interacting with the farebox and operator on the vehicle; and multi-door boarding/alighting, which maximizes the number of passengers who can board and alight at once. Since low-floor boarding is assumed for any fleet modernization scenario, we will focus our analysis on the latter two attributes.

Industry standard default values[4] for per-boarding-passenger service time range from 3 to 5 seconds for SEPTA's token (3s), cash (4.5s), and magnetic stripe (5s) fare mix. For the purposes of this analysis, we will conservatively assume a value of 4.0 seconds for current operations. In comparison, per-boarding-passenger service times of 1.75 seconds are suggested for "no fare payment," or fare prepayment. Standard per-passenger rear-door alighting times are also 1.75 seconds. The same guidance also indicates that per-passenger boarding and alighting service times are reduced by 40% and 25%, respectively, with the addition of a second entry/exit point[5].

Averaging the two sets of boarding and alighting values (the ones that match existing SEPTA trolley operations, and the ones that match a fare prepayment and multi-door boarding/alighting scenario) yields an overall dwell time estimate of 2.9 seconds per boarding or alighting passenger under existing trolley operations, and 1.2 seconds under a modernization scenario—an overall reduction of 59%[6].

FINDINGS

Applying our estimate of 59% for the reduction in dwell times that would be experienced under a multi-door boarding/alighting and fare prepayment scenario, to our 5-minute estimate for running time available to be saved for the Route 34 trolley (AM peak eastbound) yields an estimated reduction of roughly 3 minutes in overall end to end running times—or 16.7%.

We believe this estimate to be realistic, given that it was calculated using a series of conservative assumptions, and broadly transferable to other City routes that operate similarly. However, to be still more conservative given the realities and messiness of real world street operations, we suggest using an estimate of 15% for your systemwide scenario calculations (for surface operations).

[4] Transit Capacity and Quality of Service Manual (TCQSM), 3rd Edition, 2013 (p. 6-7).
[5] Transit Capacity and Quality of Service Manual (TCQSM), 3rd Edition, 2013 (p. 6-68).
[6] For a peer 'ground truth,' this compares with a reduction in per-passenger dwell times from 3.52s to 1.12s (68%) experienced by MTA/New York City Transit for the Bx41 Select Bus Service (SBS) project, following equivalent fare payment and boarding/alighting changes.

ADDENDUM: A NOTE ON TUNNEL RUNNING TIMES

Since trolley peak vehicle requirements are a function of running times for the entire route, rather than just the surface portion (for subway-surface routes), it is desirable to have a comparable estimate for running time savings that could be achieved underground based on equivalent fare payment and boarding/alighting changes at 19th, 22nd, 33rd, 36th, and 37th Street stations, which would be gated under a proof-of-payment scenario to reduce potential fare evasion.

The tunnel is a very different operating context from the surface: trolleys have their own, dedicated right of way, and so there is no delay related to other vehicles. However, all of the subway-surface routes mix for the tunnel “trunk” portion of their alignments, and the tunnel’s signal system (which ensures a safe distance between trolleys, among other attributes) limits trolley speeds and tunnel capacity. However, if we liberally assume that tunnel capacity would be available to accommodate faster end-to-end trolley travel times resulting from reduced dwell times at stations—which presumably becomes a more reasonable assumption under an articulated trolley procurement scenario, since line capacity could be achieved through fewer vehicles—it is possible to calculate a rough estimate for running time savings that could be achieved for subway portions of the route.

From the same Fall 2013 Route 10 APC data reviewed above, the average time stopped serving passengers at 19th, 22nd, and 33rd streets was 48 seconds; the average time stopped at stations for any other reason was negligible: 1 second. If we apply our estimated 59% dwell time reduction for prepayment and multi-door boarding/alighting to the difference (47 seconds), we can estimate an average time saved per subway stop of 27.7 seconds. Assuming—again—transferability between routes and stations, multiplying this estimate by Route 34’s five subway stations that are not already gated yields an estimate of 2.3 minutes saved per run, or 17.7% of Route 34’s scheduled 13 minute subway running time. As a result, under the series of assumptions made here, it is reasonable to apply the 15% running time savings conservatively estimated above for surface operations to the entire route, including subway portions.

Appendix B

April 2015 memorandum on ADA ramp deployments, as transmitted

DELAWARE VALLEY dvrpc REGIONAL PLANNING COMMISSION ··· memo

Date: April 24, 2015

To: E. Johanson, SEPTA

From: D. Dobson, DVRPC; T. Stead, DVRPC

Subject: ADA Curb Ramp Operational Considerations for Trolley Modernization

SEPTA is planning to replace its aging trolleys in order to accomplish four main goals: create a fully accessible system, improve customer experience, control vehicle acquisition costs, and reduce annual operating costs. This upgrade requires SEPTA to comply with Americans with Disabilities Act (ADA) standards that would require trolley access to riders that require an ADA-compatible ramp to board a vehicle. DVRPC has studied the operational implications of boards and alights that require ADA ramp deployments on modern trolley vehicles.

The “ADA ramp deployment rate” counts instances in which an ADA ramp deploys on a SEPTA vehicle. While ADA ramps provide access for wheelchair users, these ramps can also deploy for passengers with mobility challenges that require other mobility aids, such as mobility scooters, assistive canes, crutches, and walkers. The ramp can also be deployed for those who have difficulty with walking up steps, such as older adults, people with temporary physical injuries, or passengers who have small children. Furthermore, passengers with large strollers or a large amount of baggage (groceries, suitcases, etc.) could also benefit from an ADA ramp.

On current SEPTA buses and the accessible Route 15 trolley, passengers using the ADA ramps typically take longer to board because the ramp must be deployed by the vehicle operator. Following the ramp deployment, an operator must ask the passenger if assistance is needed to secure a mobility aid into place and assist the passenger if desired. Additional dwell time can occur when other passengers must move from the accessible seating area to accommodate passengers with mobility devices. Modern trolleys may help to reduce the amount of operator assistance required with user-automated boarding ramps, but any vehicle utilizing ADA ramps increases dwell time.

The ADA ramp deployment rate is one of many factors (such as multidoor boarding time savings, stop consolidation, stop design, and vehicle speed) that determine the time it takes for a trolley to complete its route. SEPTA vehicle procurement numbers are also dependent on how quickly a vehicle can complete its route in order to maintain a desired headway and level of service. This memo uses SEPTA data to estimate the percentage of runs that would experience an ADA ramp deployment on new modern trolley vehicles. This rate is an estimate (for forecasting purposes) of ADA ramp deployment’s impact on speeds and overall run time.

For simplification of this analysis, future population and ridership forecasts were not quantified, though a general trend toward an aging population and greater demand by seniors is acknowledged. This general assumption is reflected in the final ADA ramp deployment rate estimate.

DVRPC staff used two different approaches to estimate an ADA ramp deployment rate for modern trolley vehicles. The rate determined using each method is compared to find an overall ADA ramp deployment rate estimate:

- Method A examines *current ADA ramp deployment rates* on a sample of buses, as well as the Route 15 trolley, which operate a portion of their service in West Philadelphia near trolley routes proposed for modernization.
- Method B determines a daily trip rate estimate for *Customized Community Transportation (CCT) and disabled reduced fare eligible registrants* living within a quarter or eighth of a mile from West Philadelphia trolley lines. Registrants in these programs are likely to use the ADA ramp.

Additionally, this memo provides supplemental information on ADA ramp deployments: DVRPC mapped ADA ramp boards and alights to locate stops where the ADA ramp was more frequently deployed (e.g., near medical facilities). ADA board and alight times from peer streetcar/light rail cities, as well bus ADA ramp deployments, were also compared to examine possible additional dwell times associated with ADA boards and alights.

With an estimated ADA deployment rate and estimated time taken per board or alight, ADA ramp deployment activity can appropriately be accounted for in the ongoing DVRPC operations analysis for SEPTA trolley modernization.

Section 1: Estimating ADA Ramp Deployment Rates for Trolley Modernization

Method A: ADA Ramp Deployment Rates for West Philadelphia Buses and Route 15

DVRPC examined ADA ramp deployment rates for existing West Philadelphia routes 31, 52, 64, 108, 15, and 21/42 *(shown on page B17)* in an effort to better understand how future modern trolley service may be affected by boards requiring ADA ramp deployment.[1] SEPTA provided DVRPC with boarding data collected between late August and November 2014 that captured each time an ADA ramp deployment occurred. This data is referred to as "Observed ADA Ramp Deployments" within Method A. SEPTA also provided an "estimated" daily ADA Ramp Deployment rate for each route from a recent 90-day ADA ramp user count. These rates were used to check the observed data to ensure that the ADA deployment rates were reasonably close (*see "SEPTA Estimated ADA Ramp Deployments" in Table B-1)*.

Using the following approach, staff found the percentage of daily vehicle trips that an ADA ramp is deployed for each of the selected routes:

1. First, the observed number of daily average ADA ramp deployments was found by counting the total ADA ramp deployments per route and dividing it by the total span of days in which ADA ramp deployments were observed (*see Table B-1).*

Table B-1: Total and Average Daily ADA Ramp Deployments for Selected West Philadelphia Routes				
	SEPTA Estimated ADA Ramp Deployments	Observed ADA Ramp Deployments		
Route	*SEPTA Estimated* Daily Avg. Ramp Depl.	*Observed* Ramp Depl.	*Observed* Days	*Observed* Daily Avg. Ramp Depl. (Obs. Ramp Depl./Days Obs.)
15	8	631	88	7
21/42	15	1,476	92	16
31	3	407	93	4
52	4	421	92	5
64	5	609	93	7
108	2	153	93	2

[1] Route 15 trolley and ADA ramp deployments were combined in this study because the Route 15 bus is intended to provide equivalent substitute service during I-95 construction for the eastern portion of the trolley route. Additionally, the bus is occasionally used as a substitute for the trolley and runs along the same route. Due to its typically shorter running length, the 15 bus thus experienced fewer ADA ramp deployments. SEPTA also combined raw ADA ramp deployment data for the 21 and 42 buses, likely due to their merged route in Center City and their parallel routes through West Philadelphia. These routes were combined to create a single daily ADA ramp deployment rate.

2. Next, using *SEPTA's 2014 Route Statistics*, a daily average service level was developed using the number of trips per route on an average day.[2] The daily average service level for each route is shown in *Table B-2.*

Table B-2: Daily Average Service Levels By Route (Trips Per Day)					
Route	Weekday	Sat.	Sun.	Total (Wkday*5)+Sat+ Sun	Daily Avg. Svc. Level (Total/7)
15	196	148	146	1,274	182
21/42	454	320	264	2,854	408
31	99	60	46	601	86
52	336	226	176	2,082	297
64	121	72	67	744	106
108	159	81	71	947	135

3. The final step in Method A is to find the percentage of all trips in which an ADA ramp is deployed by dividing daily average service (bus routes) by daily average ADA ramp deployments for both observed and SEPTA estimated trips. The results can be found in *Table B-3.*

Method A Results:

When analyzing the observed trip rate to see how many trips deployed an ADA ramp (*Table B-3*), the routes fell into a range of 1.2 percent to 6.2 percent (Route 108 the fewest, Route 64 the highest). The SEPTA-estimated trip rates fell into a very similar range of 1.3 percent to 4.9 percent, with the highest divergence (roughly 1 percent) occurring on the 64 and 31 routes. The observed daily ADA ramp deployment rate average is 3.6 percent and the observed daily ADA ramp deployment rate median is 3.7 percent.

Method A's findings will be compared to Method B later in this memo to develop an overall estimated ADA ramp deployment rate for West Philadelphia modern trolley routes. This comparison will use the median observed daily ADA ramp deployment rate of 3.7 percent.

Table B-3: Daily Percentage of Trips with an ADA Ramp Deployment		
Route	SEPTA Estimated Ramp Depl. Rate	Observed Daily Ramp Depl. Rate
15	4.4%	3.9%
21/42	3.7%	3.9%
31	3.8%	5.1%
52	1.2%	1.5%
64	4.9%	6.2%
108	1.3%	1.2%
Observed Daily Ramp Depl. Rate Range:		1.2%–6.2%
Observed Daily Ramp Depl. Rate Avg.:		3.6%
Observed Daily Ramp Depl. Rate Median:		3.7%

Percentage of Trips With a Ramp Deployment:

$$\frac{\text{Daily Average Service Level (Table 2)}}{\text{[Obs. or Est.] Daily Average Ramp Deployments (Table 1)}}$$

[2] SEPTA Service Planning Department, *2014 route statistics*. http://septa.org/strategic-plan/reports/route-statistics.pdf

Method B: Paratransit and Disabled Reduced Fare Rates

Method B examines Philadelphia County CCT paratransit and disabled reduced fare registrants and trip rates as an alternative way to approximate the percentage of trips with an ADA ramp deployment on West Philadelphia trolleys if modernized. This portion uses West Philadelphia Trolley Routes 10, 11, 13, 34, and 36. Route 15 is excluded because it is included in Method A and is substantially different from the other routes because it is currently ADA compliant.

The types of registrants examined, shown in *Table B-4,* are broken into five categories: ADA, Shared Ride Program, CCT (two different rates), and Disabled Reduced Fare:

Table B-4: Types of Registrants Enrolled in SEPTA CCT or Reduced Fare Programs	
Type	Description
Americans With Disabilities Act (ADA)	ADA registrants with "architectural barriers" were counted, rather than those with other disabilities (e.g., hearing, developmental). Defined by SEPTA, examples of architectural barriers include, but are not limited to, lack of sidewalks, curb ramps, obstructed paths of travel (due to broken sidewalks, tree roots, construction, etc.), and crossing major highway/four-lane street.
Shared Ride Program (SRP)	SRP registrants are adults 65 years or older who ride CCT. There may be some registrants who are classified as "SRP registrants" who have physical disabilities.
Customized Community Transportation (CCT)	All registrants eligible for paratransit service. This is a combination of the ADA and SRP registrants. For this analysis, two different daily trip rates are created: "*CCT (combined)*" that uses the average rate of all CCT users, and "*CCT (separated rates)*" that uses two rates for ADA registrants and SRP registrants and adds them together.
Disabled Reduced Fare	SEPTA riders who receive reduced fares that have a variety of disabilities, such as physical, mobility, sight, and/or hearing impairments.

1. DVRPC chose to analyze Philadelphia County data because the majority of trolley surface routes lie within Philadelphia boundaries. Additionally, the suburbs have different trip rates influenced by a variety of factors. For simplification of analysis, DVRPC assumes each CCT record is a unique person, although a person may qualify under both programs.
   SEPTA provided DVRPC with the total number of CCT and disabled reduced fare registrants ("*City Total" in the Registrants column in Table B-5*). This method examines registrants and not customers. A person can be registered for reduced fare or CCT service but not travel the system frequently or at all.[3]

[3] SEPTA. (2014, June). "CCT Connect Trend Analysis Completed Patron Trips 2014". PowerPoint Presentation.

SEPTA also provided the total trips for each registrant type, each of which needed to be converted to Daily Average Trips. For CCT trips by registrant type, DVRPC used an annual trip number from the *2011–2014 Fiscal Year Trend CCT Analysis* provided by SEPTA. For the number of disabled reduced fare trips, DVRPC used SEPTA-provided monthly linked trip counts from SEPTA's 2008 *and* 2009 fiscal years.

A **daily average trip rate** was created to provide an average rate for each registrant type across the City of Philadelphia. The CCT annual trips and three-month average disabled reduced fare trip counts were converted to daily average trip numbers ("*Daily Avg." column of Table B-5).* After this, each daily average trip number is divided by registrants (e.g. for ADA 1,844/9,215= 20 percent) to produce the daily average trip rate (*"Daily Average Trip Rate" column in Table B-5*).[4]

Table B-5: Daily Trips Rate for Each Registrant Category in Philadelphia: CCT vs. Reduced Fare

		Registrants	Total Trips		Daily Avg. Trip Rate
	Registrant Type	*City Total*	*Annual*	*Daily Avg.*	*Daily Trips/Registrants*
CCT	ADA	9,215	673,094	1,844	20.0%
CCT	SRP	22,473	631,574	1,730	8.0%
CCT	CCT	28,700	1,304,668	3,574	12.5%
	Month	*Red. Fare City Total*	*Monthly*	*Daily*	*Daily Trips/Registrants*
Reduced Fare	Oct-08		126,849		
Reduced Fare	Mar-09		158,329		
Reduced Fare	Nov-10		175,041		
Reduced Fare	*Three Month Avg.*	14,182	153,406	5,114	36.0%

2. The next step was to determine, with trolley modernization, the **number of additional daily trips** taken on West Philadelphia trolleys by registrants who live near West Philadelphia trolley lines. This analysis assumes that 100 percent of the trips made by those who are registered with CCT or have disabled reduced fares will use modern, ADA-accessible trolleys. This conservative assumption results in a higher than likely rate for each registrant category.

   Using home addresses provided by SEPTA, DVRPC staff mapped an **eigth-mile and quarter-mile buffer from the West Philadelphia trolley lines** to see how many registrants live within the buffers for each of the five rates (this map is shown on page B17, while *Table B-6 "Registrants" column* shows the results for each rate category). The eighth- and quarter-mile radii were chosen as reasonable distances for registrants to access a trolley line from home. Although 1/8 of a mile is a short distance (about one city block), limited-mobility registrants might not be able to travel long distances from home. Additionally, when cross-checking the results, the 1/4 mile radius created results that were much higher than the ADA ramp deployment rates from Method A or any known rates actually experienced by SEPTA routes.

[4] SRP users and ADA users have similar annual total trip numbers, but there are many more SRP registrants. Therefore, SRP has a much lower daily rate trip than ADA registrants.

Table B-6 shows additional daily trips taken by registrants living within an eighth- and a quarter-mile from West Philadelphia trolley lines. The additional daily trips are found by multiplying the average number of trips per registrant type by the number of registrants within each buffer. For example, ADA registrants that live within an eighth of a mile of a trolley line would add an additional 68 trips per year on trolleys if they were accessible.

Table B-6: Registrants and Additional Daily Trips within an Eighth and a Quarter Mile of West Philadelphia Trolley Lines, Assuming a 100 percent Mode Shift to Modernized West Philadelphia Trolleys				
Service Type	Eighth-mile Radius		Quarter-mile Radius	
	Registrants	Additional Daily Trips ([reg. type] daily trip rate * registrants	Registrants	Additional Daily Trips ([reg. type] daily trip rate * registrants
ADA	340	68	658	117
CCT	1,146	88	2,035	157
CCT (ADA+SRP)	1,486	152	2,618	267
ADA+SRP (separate rates)	1,486	156	2,618	273
Disabled Reduced Fare	936	333	1,146	527
Additional daily trips within an eighth- or quarter mile of West Philadelphia trolley routes.				
[Registrant Type] Daily Trip Rate (*Table B-5 Daily Trip Rate*) * Registrants within W. Phila. Trolley Route Radii				
Example ADA 1/8 Mile	20% * 340 = 68			

3. Next, the combined West Philadelphia daily average service (the average total daily trolley trips) are calculated for each one of the West Philadelphia routes similar to the calculation in Method A's Table B-2 (with current SEPTA bus routes). Since Method B examines registrants on all West Philadelphia trolleys together rather than examining daily average service for individual routes (such as in Method A), all routes were added together for one daily average service number See *Table B-7*).

Table B-7: Daily Average Service for Combined West Philadelphia Trolley Routes					
Route	Weekdays	Saturday	Sunday	Total (Wkdy*5) + Sat. + Sun.	Daily Avg. Service (Total/7)
10	280	146	132	1,678	240
11	240	132	124	1,456	208
13	314	144	126	1,840	263
34	308	156	145	1,841	263
36	310	152	130	1,832	262
West Philadelphia Trolley Routes Daily Average Service					1,235

4. Lastly, daily trips per registrant type were divided by the average trolley trips per day to produce a rate for each (*see Table B-8)*.

Method B Results:

Assuming that each registrant category experiences a total shift to modern West Philadelphia trolleys, 5.5–26.9 percent of trolley runs would include a registrant from the ADA or disabled fare programs using an eighth-mile buffer and 9.4–42.7 percent using a quarter-mile buffer.

The lowest estimated trip rates were for ADA registrants, while disabled reduced fare rates were by far the highest. Since there are many fewer ADA registrants than other registrant types, this rate intuitively should be lower. The disabled reduced fare rates are much higher than the other rates because this rate accounts for all types of disabilities and therefore has many more registrants.

Table B-8: Estimated Daily Percentage of West Philadelphia Trolleys with CCT or Reduced Fare Registrant Boardings

Registrant Type	Eighth-mile Daily Trip Rate	Quarter-mile Daily Trip Rate
ADA	5.5%	9.4%
SRP	7.1%	12.7%
CCT (ADA + SRP)	12.3%	21.6%
ADA + SRP (separate rates)	12.7%	22.1%
Disabled Reduced Fare	26.9%	42.7%
Daily Trip Rate by Registrant Type		
[Registrant Type] Daily Avg. Trips (Table B-6) / 1,235 (West Philadelphia Daily Average Service [*Table B-7*]		
ADA Registrant, Eighth-mile Buffer Example	68 / 1,235 = 5.5%	

This analysis assumes that all of these trips will need an ADA ramp deployed. Realistically, while it is likely that many of the ADA registrants will likely need an ADA ramp deployed, it is less likely that a registrant enrolled in the disabled reduced fare will need the ramp deployed since this program includes a variety of disabilities.

The ADA eighth-mile trip rate of 5.5 percent (highlighted at the top of Table B-8) seems to be the best estimate of ADA ramp deployments to represent Method B. At present, ADA paratransit customers are not required to use transit because they have physical barriers keeping them from access. Although the eighth-mile ADA rate is the lowest rate in this analysis, it is the most sensible because it bears the closest resemblance to rates shown along currently accessible routes in Method A. Additionally, the assumption that 100 percent of registrants would shift to West Philadelphia trolley routes is also a higher estimate than DVRPC predicts will actually occur. Furthermore, the ADA registrants are the most likely registrant group to consistently require ADA ramp deployment.

Conclusions: Comparing Methods A and B to Inform a Composite "Best Guess" Estimate

Method A shows how many ADA ramp deployments are currently occurring along ADA-accessible routes in the vicinity of proposed trolley modernization routes as a means of estimating future use, while Method B estimates the trip rates of CCT and reduced fare registrants within an eighth and a quarter of a mile of the trolley routes themselves.

Using a slightly higher rate than those estimated from existing routes takes into account the reasonable but not quantified assumption of induced demand associated with a new, high-quality option for accessible travel. Such induced demand may increase the number of ADA users on fixed route systems and/or increase the overall volume of ridership for all users.

The estimated ADA ramp deployment rate of 6 percent (see Table B-9) is a reasonable round number, consistent with SEPTA's previous predictions on ADA ramp deployment rates. Additionally, the 6 percent estimate accounts for an aging population with growing senior demand, which will likely increase ADA ramp deployment demand.

Table B-9: Method A and Method B Compared

Method	Daily Ramp Deployment Rate	Rate Estimate Obtained
A	3.7%	Median West Philadelphia ADA Ramp Deployment Rate
B	5.5%	ADA Registrant Trip Rate Eighth Mile
Estimated ADA Ramp Deployment Rate for West Philadelphia Trolley Routes		6%

Section 2: Locations with High ADA Ramp Deployments

Boards and alights deploying ADA ramps along transit routes can affect stop placement and design. Stop locations where the ADA ramp deploys more frequently increase dwell time because these passengers often need additional time compared to an average passenger. With this in mind, DVRPC mapped instances in which passengers used ADA ramps to board and alight buses using a subset of Method A's bus route dataset (Routes 21, 31, 42, and 64). Although board and alight counts were considered separately, many stops with high boards also had high alights. Due to higher numbers, these locations also have a higher chance of both boarding and alighting occurring during the same vehicle stop. Reported boards and alights are shown where ADA ramp users are travelling from (origins) and to (destinations) along the bus routes, highlighting major high-use locations.

When analyzing boarding and alighting locations, a fairly even distribution of trips was observed overall in Central and West Philadelphia. Downtown Center City had the highest number of boards and alights. This is expected due to higher boards and alights in general, as well as the high number of offices and other employment centers. Additionally, two particular land uses had more ADA ramp boards and alights than an average stop did:

Medical Facilities

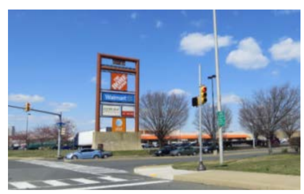
Medical facilities throughout the city, such as West Philadelphia's VA Hospital and Center City's Thomas Jefferson Hospital, experienced high levels of use and had among the highest numbers of boards and alights using ADA ramps.

Thomas Jefferson Hospital
Photo Credit: Jefferson Hospital

VA Hospital
Photo Credit: Joel Bayan

Shopping Centers

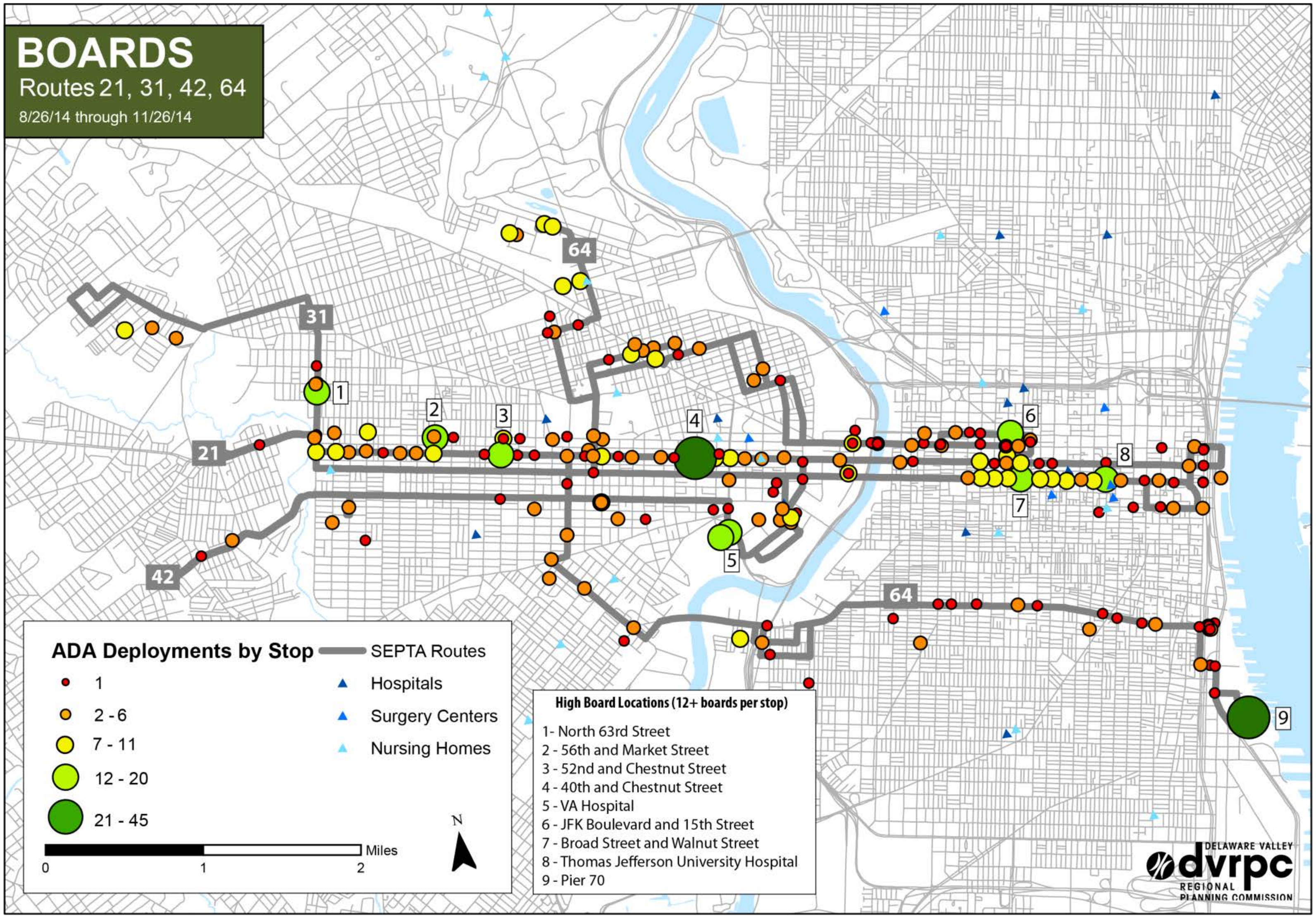
Pier 70 is a major shopping complex along South Columbus Boulevard south of Tasker Street featuring major retailers such as the Home Depot, Walmart, and a Superfresh supermarket. This stop experienced the highest overall number of boards and alights using an ADA ramp, suggesting that customers who use ADA ramps are using transit to make everyday utility trips, as well as those related to medical visits. Additionally, shopping locations in Center City had high boards and alights using ADA ramps, including stops near the Rittenhouse Square shopping district, as well as stops near The Gallery Mall.



Pier 70
Photo Credit: Adam Elmquist

Rittenhouse Row
Photo Credit: myphillycondo

To summarize, geographically dispersed origins and destinations, combined with a diversity of journey types, indicate that trips featuring ADA ramp deployments are varied by nature. However, medical centers seem to generate higher-than-typical passenger boardings and alightings that use the ADA ramp. The VA Medical Center, a location in which many passengers would require an ADA ramp, is less than a quarter-mile from the 40th Street Trolley Portal which serves four trolley routes. With this in mind, erring toward higher, more conservative ADA ramp deployment rates, as suggested in Section 1, is prudent for planning purposes. Additionally, SEPTA should avoid eliminating stops where the ADA ramp is frequently deployed if stop consolidation occurs, as well as accommodate the needs of passengers requiring ramp access in physical station designs.



BOARDS
Routes 21, 31, 42, 64
8/26/14 through 11/26/14
64
31
21
42
64
1
2
3
4
5
6
7
8
9
ADA Deployments by Stop
1
2 - 6
7 - 11
12 - 20
21 - 45
SEPTA Routes
Hospitals
Surgery Centers
Nursing Homes
Miles
0
1
2
N
High Board Locations (12+ boards per stop)
1- North 63rd Street
2 - 56th and Market Street
3 - 52nd and Chestnut Street
4 - 40th and Chestnut Street
5 - VA Hospital
6 - JFK Boulevard and 15th Street
7 - Broad Street and Walnut Street
8 - Thomas Jefferson University Hospital
9 - Pier 70
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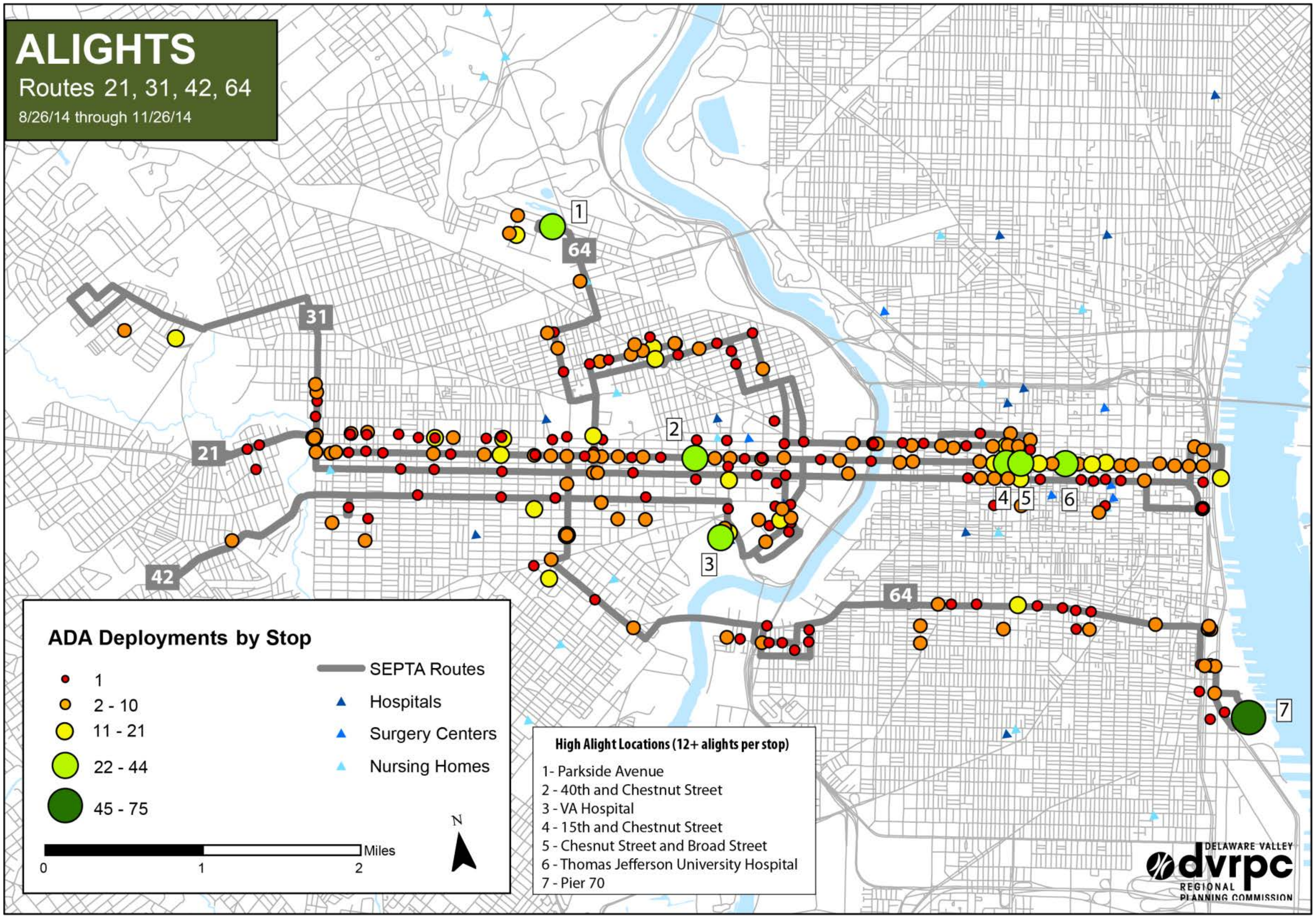
ALIGHTS
Routes 21, 31, 42, 64
8/26/14 through 11/26/14
ADA Deployments by Stop
1
2 - 10
11 - 21
22 - 44
45 - 75
SEPTA Routes
Hospitals
Surgery Centers
Nursing Homes
Miles
0
1
2
N
High Alight Locations (12+ alights per stop)
1- Parkside Avenue
2 - 40th and Chestnut Street
3 - VA Hospital
4 - 15th and Chestnut Street
5 - Chesnut Street and Broad Street
6 - Thomas Jefferson University Hospital
7 - Pier 70
21
31
42
64
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<u>Section 3: ADA Ramp Board and Alight Times in Peer Cities</u>

In addition to the percentage of vehicle trips with ADA ramp deployments, the amount of time a passenger takes to board and alight a vehicle using an ADA ramp is also crucial for modeling trolley run time. To find approximate estimates, DVRPC examined a series of YouTube recordings that show a customer in a wheelchair boarding and alighting via an ADA ramp from different light rail and streetcar systems, as well as one physical observation from a SEPTA bus. For the majority of the YouTube videos, the vehicles were not very crowded, so the wheelchair passenger could enter and exit without waiting for other passengers. Furthermore, the *Transit Capacity and Quality of Service Manual (TCQSM*) provided additional guidance for examining ADA ramp deployment dwell times.[5]

Although there are other types of users who use the ADA ramps, as noted earlier, the majority of these recordings focus on the experience of an actual person using a wheelchair. Passengers who use the ADA ramp for other reasons are likely to also need more time to board than the average passenger.

The *TCQSM* suggests that places with high and regular ADA ramp use (such as the locations shown in the previous section) will have longer boarding and alighting times that should be specially accounted for, whereas places with fewer ADA boards should use an average time to account for dwell time variability.

Table B-10: Vehicle Options for VISSIM Traffic Modeling

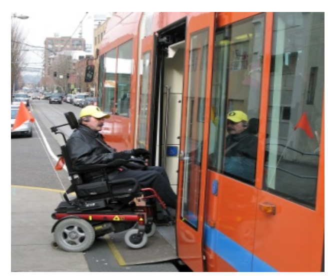
Vehicle Option	Description	Examples	Photo
Vehicle Option A-Operator Assisted Boardings:	These vehicles board wheelchair customers by a vehicle operator deploying a ramp and assisting the passenger. This type of vehicle is similar to the current vehicles on the SEPTA Route 15 trolley, with the difference being that the Route 15 uses a vertical lift rather than a horizontal ramp.	MBTA T (Boston)	
Vehicle Option B-Passenger Activated Ramps	Wheelchair passengers deploy an accessible ramp without operator assistance. Although there may be stops that do not use ramps and have level boarding (busier downtown stations in particular), this analysis focuses on when the ramp is actually deployed in these systems. For all of these instances, none of the passengers ask for operator assistance (although it can be requested if needed).	MAX light rail (Portland) Portland Streetcar (Portland) TTC Streetcars (Toronto)	

Photo Sources: http://www.mbta.com/uploadedimages/Riding_the_T/Accessible_Services/Accessible_Services_List/LR9R.jpg; [3]
http://www.railroadforums.com/forum/showthread.php?5256-Portland-Streetcar-questions/page3

DVRPC will model two vehicle types in the Trolley Modernization microsimulation (VISSIM) traffic model, each ADA accessible. These are: vehicles with operator-assisted ADA ramp boards (Vehicle Option A) and a

[5] Transportation Research Board. 2013. Transit Capacity and Quality of Service Manual. TCRP Report 165. Third Edition.

modern streetcar vehicle with passenger-activated ADA ramps (Vehicle Option B). Low-floor light rail systems with level ADA boarding (as opposed to light rail with ADA ramps) were also reviewed for comparison, although these vehicles will not be modeled.[6] A summary of the two vehicle types is shown in Table B-10

ADA Ramp Boards:

Five of the six systems (TTC, Portland Streetcar, Portland MAX, DART, and RTD) analyzed had videos featuring customers in wheelchairs boarding accessible vehicles via ADA ramps. The amount of time the vehicles stopped for boarding depended heavily on the number of other customers boarding at the stop. If the stop was not busy, the ramp could be deployed immediately. For busier stops, ADA ramp boarding did not seem to occur until other users had already boarded. In vehicles with multidoor boarding, passengers often move to another door so that ADA ramp boarding does not slow the process of others entering the vehicle. Vehicle Option A (Operator Assisted) boards ADA passengers in around 70 seconds, while Vehicle Option B (Passenger Activated Ramps) boards an ADA passenger in around 25 seconds. Overall, longer boarding times are required for vehicles needing operator assistance. *(See Table B-11.)*

Table B-11: Wheelchair Boarding Time Estimates by Vehicle Type

Vehicle	Systems Observed (City)	Estimated Boarding Time (Seconds)	Notes
Vehicle Option A: Operator-assisted	MBTA T (Boston)	70	This type is estimated to take a significant amount of time because the operator has to leave the driver cab, deploy the ADA ramp, and assist the customer.
Vehicle Option B: Passenger-activated	TTC Streetcars (Toronto) Portland Streetcar (Portland, OR) MAX Light Rail (Portland, OR)	25	In general, the doors take two to three seconds to open, and ramps take five to eleven seconds to deploy or return into place. On a semi-crowded Portland Streetcar platform, a wheelchair passenger was observed boarding in approximately 30 seconds with a user-activated ramp.
Accessible Bus	SEPTA bus (Philadelphia) Low-floor bus (TCQSM Manual) Lift buses (TCQSM Manual)	60	Usually around a minute, but for rare instances with inexperienced users or those with more serious physical disabilities, boarding can take much longer (up to 200 seconds).
Light Rail Transit Low-Floor	DART (Dallas) RTD (Denver)	12	Much faster than either option, but not as common for streetcar/trolley systems.

[6] Although the videos observed were from low-floor light rail systems, some trolley/streetcars are moving toward low-floor vehicles, such as the DC Streetcar system and some European systems. These vehicles do not use ramps and have fully accessible boarding at all stations.

ADA Ramp Alights:

Due to a limited number of samples (videos only from Boston MBTA T, Denver RTD, and Portland Streetcar), it is difficult to determine how long alighting will take wheelchair- and other ADA ramp-dependent passengers. However, boarding passengers typically take longer than those alighting, regardless of whether there is an ADA ramp-dependent passenger. Some factors that make alighting shorter are shown in *Table B-12*:

Table B-12: Comparison of Wheelchair Boarding and Alighting Factors

	Boarding	Alighting
Creating Space for Wheelchair Passengers	Often, other passengers must relocate to accommodate a wheelchair passenger before the vehicle moves again.	After the wheelchair passenger exits, other passengers can optionally choose to relocate, but it is not required for the vehicle to move.
Ramp Activation	A wheelchair passenger must press the ramp button on the vehicle when it stops, depend on an operator seeing the passenger, or actually be assisted by the operator.	Exiting the vehicle, the passenger can press a button in advance to cue the ramp for the next station or let the operator know beforehand their destination.

Furthermore, the Portland Streetcar examples (in which there are boarding and alighting instances) show that it is faster to leave the vehicle than board (25 seconds versus 20 seconds). With this in mind, Vehicle Option B (Passenger-activated Ramps) will assume alight times of around 20 seconds. With Vehicle Option A, the operator still has to stop and assist the passenger. As a result, Vehicle Option A (Operator-Assisted) will assume alight times of around 60 seconds. A summary of alighting times is shown below in *Table B-13:*

Table B-13: Wheelchair Alighting Time Estimates by Vehicle Type

Vehicle	Systems Observed (City)	Estimated Boarding Time (Seconds)	Notes
Vehicle Option A: Operator-assisted	MBTA T (Boston)	60	This type is estimated to take a significant amount of time because the operator has to leave the driver cab, deploy the ADA ramp, and assist the customer. This number is shorter than Vehicle Option A's boarding time, but still takes longer than Vehicle Option B due to operator assistance.
Vehicle Option B: Passenger-activated	Portland Streetcar (Portland, OR)	20	ADA alighting was faster in these vehicles because passengers pressed automated buttons before the vehicle stopped to indicate that a wheelchair ramp was required at the next station.
Light Rail Transit Low-Floor	DART (Dallas) RTD (Denver)	7	Much faster than either option, but not as common for streetcar/trolley systems.

CONCLUSIONS

DVRPC recommends a 0.06 ADA ramp boarding and alighting rate estimate for forecast purposes (i.e., 6 percent of trolley trips have a passenger who will require an ADA ramp when boarding and alighting the vehicle) based on existing SEPTA West Philadelphia bus/trolley boards and alights (Method A), as well as Disabled Reduced Fare and CCT registrants (Method B).

Additionally, DVRPC suggests that SEPTA examine ADA ramp deployment considerations more closely at stops near medical facilities and shopping centers. Furthermore, DVRPC estimates that a passenger boarding using an ADA ramp will require 70 seconds for Vehicle Type A and 25 seconds for Vehicle Type B, as well as 60 seconds for alighting for Vehicle Type A and 20 seconds for Vehicle Type B. These estimates will be used as part of the ongoing VISSIM operations analysis for these two vehicle types. A summary of the recommendations can be seen in *Table B-14*:

Table B-13: Summary of Wheelchair Boarding Considerations	
Estimated Wheelchair Trip Rate	6 Percent of West Philadelphia trolley trips will experience a passenger who will require an ADA ramp when boarding and alighting the vehicle
Locations With Particularly High ADA Ramp Deployment	Medical Facilities (e.g., VA Hospital, Jefferson Hospital); Shopping Locations (e.g., Pier 70, Rittenhouse Row)
Vehicle Boarding/Alighting Times	Vehicle Type A (Operator-assisted): 70 seconds boarding, 60 seconds alighting Vehicle Type B (Passenger-activated): 25 seconds boarding, 20 seconds alighting

Figure B-1: Method A Study Routes:

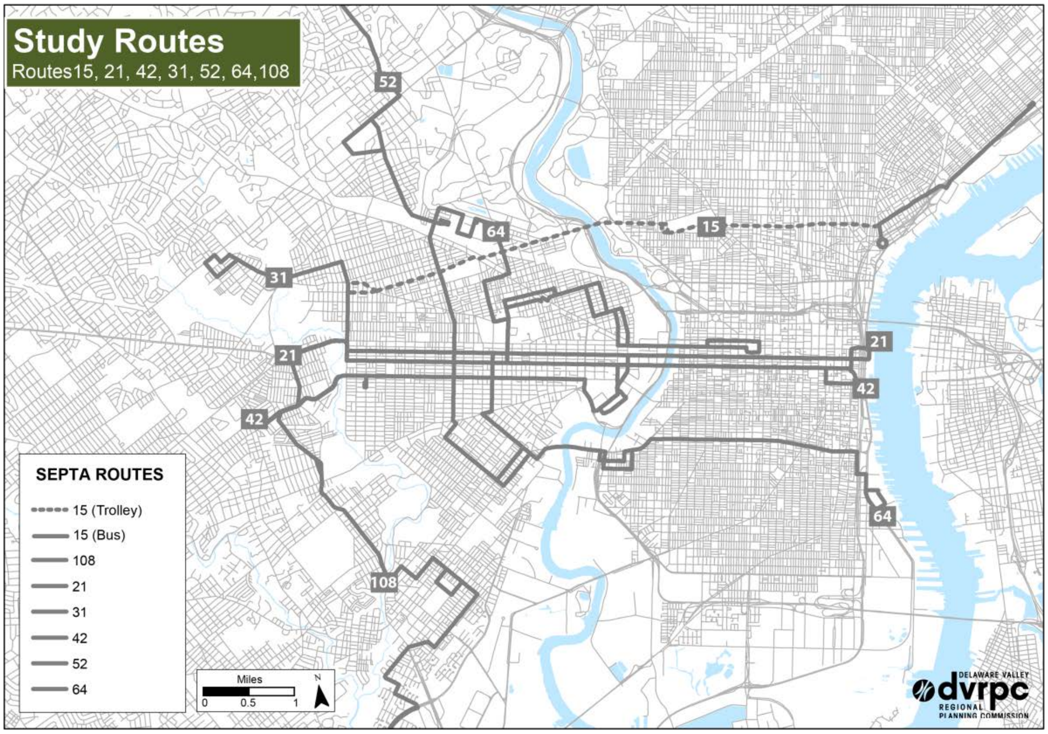
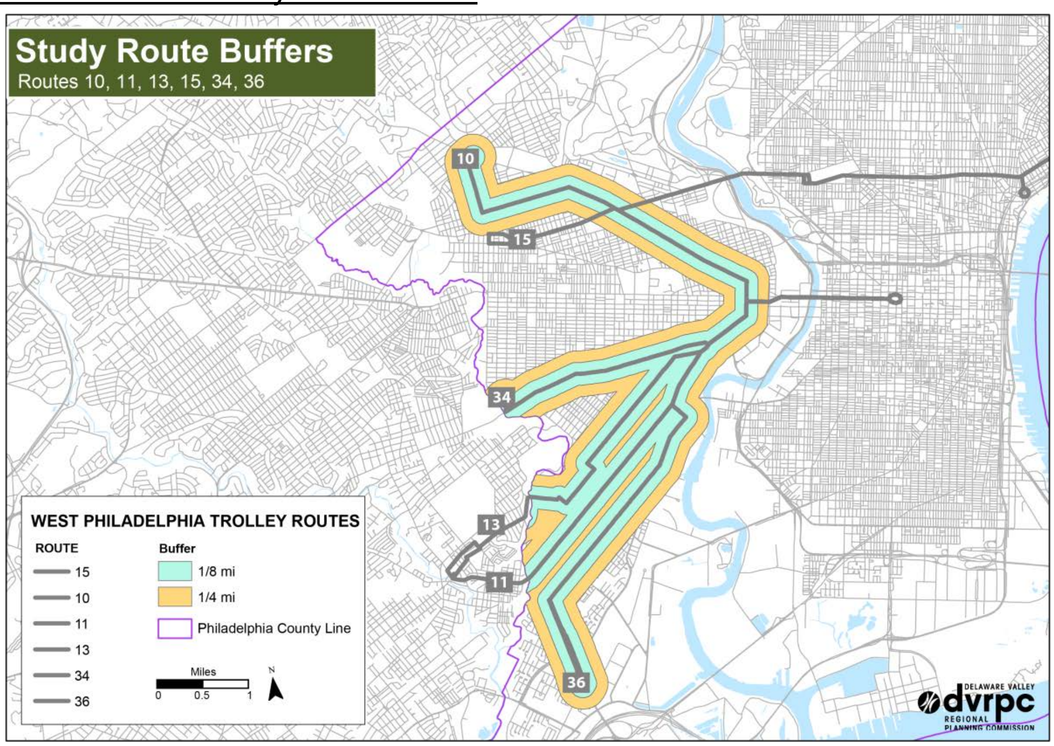


Figure B-2: Method B Study Route Buffers:



Appendix C
Details on model calibration and scenario coding

Appendix C: Details on model calibration and scenario coding

Base Version (Prior Study)

The base version of the simulation model used in this study was originally developed for an evaluation of Transit First strategies conducted in 2009–2010. This model was updated using 2014 data for the purposes of this study.

Various data elements were required to apply VISSIM to the transit simulation along Baltimore Avenue. The elements of geometry, vehicular traffic, turning movements, transit vehicle data, passenger boarding and alighting data, and signal control are discussed here.

The basic geometry along Baltimore Avenue was taken from the VISUM regional travel model. Since the regional model does not include every street, all remaining numbered and side streets between 40th and 61st streets were manually added. The roadway geometry was adjusted both before and after exporting from VISUM to VISSIM in order to properly align with DVRPC's ortho-corrected aerial images. Each intersecting street was modeled in VISSIM up to but not including the next intersection north and south of Baltimore Avenue.

Estimating the correct level of vehicular traffic is critical in order to accurately model transit operations for the Route 34 trolley. Both the overall level of traffic and turning movements at each intersection were determined by extensive traffic counts along Baltimore Avenue in January 2009. The counts are a mixture of automatic traffic recorder (ATR) volume counts, ATR classification counts, manual turning movement counts, and manual volume counts. Manual counts were needed along Baltimore Avenue and side streets that have trolley operations because rail traffic cuts the pneumatic tubes used for ATR counts. The various types of counts were processed, adjusted for consistency, and then aggregated into volumes to represent the AM peak time period from 6 AM to 9 AM. Midday counts (9 AM to 3 PM) were also estimated, but midday modeling was outside the scope of this project. The vehicle inputs on the western and eastern edges of the modeled portion of Baltimore Avenue and on all intersecting streets were also added to the model.

Volume inputs were updated using ATR volume counts taken in fall 2014 on major streets crossing Baltimore Avenue. These counts were compared to counts from the same locations from 2009. By calculating the total change in volume between the 2009 and 2014 counts, a global scaling factor was determined, which was then applied to all vehicle input locations.

Turning movements were determined from counts and adjusted for consistency in a similar manner, and average turning movements over the 6 AM to 9 AM period were then input to the model. These turning movements, for example, reflect the percentage of vehicles proceeding straight, left, or right at an intersection.

Classification counts were used to determine the percentage of each type of vehicle that operates along Baltimore Avenue. A simple model is used with only two types of vehicles for background traffic: automobiles and trucks, plus transit vehicles.

Transit vehicle data was provided by SEPTA. Important data includes maximum acceleration, deceleration, number and location of doors, and passenger capacity. Boarding and alighting rates (seconds per passenger) were estimated based on vehicle doors and geometry in conjunction with equations in the 2000 *Highway Capacity Manual*, Chapter 27. Transit vehicle departure data was determined by calculating the average headway on the Route 34 trolley from the fall 2014 schedule.

Boarding, alighting, and occupancy data for each stop was determined from Automated Passenger Counter (APC) data collected during fall 2014. Boarding data was input into the model in the form of hourly arrival rates for the AM peak hour (8 AM to 9 AM). Alighting was entered into the model as a percentage of vehicle occupants that depart at each stop. GPS location data within SEPTA's APC datasets (2014) was also used to determine transit vehicle travel time along the route, which was used to validate the model.

DVRPC obtained signal timing data from the City of Philadelphia. The signal timing plans were implemented in VISSIM using the ring-barrier controller (RBC). All of the intersections in the study area along Baltimore Avenue currently use fixed coordinated signal systems operating on a 60-second cycle. The majority have a two-phase 40-second/20-second split in favor of traffic on Baltimore Avenue.

Calibration Updates

In order to update the original base model on which the simulation model for this study was built, several sets of inputs had to be checked and updated. The most notable of these changes were updates to the boarding and alighting inputs for Route 34 and updates to automotive traffic inputs.

Hourly rates for boarding and alighting for the Route 34 trolley were updated using APC data from SEPTA for the fall 2014 period. This data is collected across multiple days for all vehicle journeys and allows for the averaging of many observations to provide an accurate estimate of daily and hourly demand.

The average boarding time per passenger was adjusted from over 7 seconds—used in the 2009 calibration—to 5 seconds. This 5-second value was selected as the reasonable industry-standard upper bound for average boarding time, as per this project's "Memorandum on Running Time Savings, as Transmitted" (August 2014; Appendix A). This value yielded a base-calibrated end-to-end time of 16.17 minutes, which was 9.2 percent faster than the APC average end-to-end time of 17.82 minutes. Federal Highway Administration guidance on traffic microsimulation, *Traffic Analysis Toolbox Volume III: Guidelines for Applying Traffic Microsimulation Modeling Software* (July 2004, Pub Num: FHWA-HRT-04-040), states that simulated journey times should be within 15 percent of observed values, a standard satisfied by our base calibration's end-to-end times.

Vehicle inputs were scaled according to the average change in hourly volumes at the intersections of 58th, 52nd, 48th, and 43rd streets. Counts were taken in the fall of 2014 and compared to existing counts for the same locations for 2009, and the change was averaged across the recounted locations. This comparison yielded a vehicle input scaling factor of 1.01375, which was applied as a global factor to all vehicle input points along the simulated corridor in order to approximate the change in corridor auto demand between the two years (see Table C-1).

Table C-1: Change in Automobile Volumes for Select Intersections, 2009 to 2014

Location	Original Volume	Adjusted Volume
Baltimore WB before 40th St.	219	222
40th St. SB	147	149
Springfield Ave NE B	298	302
47th St. NB	200	203
53rd St. SB	207	210
Cobbs Creek Pkwy. EB	301	305
Baltimore EB before 61st St.	408	414

Source: DVRPC 2009, 2014

During calibration, some local driveways that were part of the model also had to be consolidated and their volumes reallocated to nearby streets due to their close proximity to intersections. The volumes associated with these driveways, along with their locations in the simulation network, were causing interference that would block vehicles and cause the model run to fail through gridlock.

Coding Alternatives

For the runs involving the S70 Trolley, the length of the trolley was increased to 80 feet (in comparison to the Kawasaki trolley base case) and the width increased to 8.67 feet from eight feet. Due to the near identical specification of braking and acceleration profiles, the coded acceleration and stopping capabilities of the vehicle were kept the same. In addition to these changes to vehicle dimensions between the no-build and build alternatives, the capacity of the vehicle was increased from 85 to 149 passengers.

To simulate the boarding and alighting of individuals with disabilities, an ADA script was created that extended the trolley dwell time. It simulated both operator-assist and auto-deploy methods, the first requiring a deployment time of 70 seconds, while the second only required 25 seconds. This was set to affect 6 percent of vehicle journeys by direction during a given simulation period. Assuming greater demand for ramp deployment would of course result in higher simulated end-to-end times and corridor-delay measures. In order to replicate this effect in the model, new signal heads and detectors were put in place that only had a connection to the trolleys and did not impact any normal vehicles. These secondary signal heads would remain illuminated green until a point at which that 6 percent script triggered an ADA boarding.

Two detector types were coded at each intersection on Baltimore Avenue in order to simulate TSP. The first one encountered showed the vehicle entering the system, thereby initiating the TSP. Once the vehicle entered the system, the signal timing would be extended by 10 seconds to allow the vehicle to pass through the intersection or—in the case of a trolley stopping to pick up or drop off passengers—TSP allows for the clearing of the traffic queue ahead of the trolley. Once the trolley passed through the intersection, it was considered as having exited the system after it proceeded over the detector in place to allow the trolley to depart the TSP system. Once the vehicle properly exited the system, the signal would revert back to its normal timing operation. An important qualification to this report’s coding for TSP is that the details for TSP implementation (including the frequency at which TSP is triggered and trolley prioritization in relation to emergency vehicles) will vary based on engineering judgment.

Table C-2: Reallocation of Passengers for Stop Consolidation Scenarios

	Eastbound APC	Westbound APC	Eastbound Consolidated	Westbound Consolidated
BALTIMORE LOOP 61ST ST	71	32	71	32
BALTIMORE AV 60TH ST	20	10	21	10
BALTIMORE AV 59TH ST	13	3	0	0
BALTIMORE AV 58TH ST	43	18	57	22
BALTIMORE AV 57TH ST	27	17	0	0
BALTIMORE AV 56TH ST	16	3	40	18
BALTIMORE AV 55TH ST	28	7	30	7
BALTIMORE AV 54TH ST	16	2	0	0
BALTIMORE AV 53RD ST	19	10	33	12
BALTIMORE AV 52ND ST	34	14	36	14
BALTIMORE AV 51ST ST	24	1	0	0
BALTIMORE AV 50TH ST	35	7	57	8
BALTIMORE AV 49TH ST	46	7	46	7
BALTIMORE AV 48TH ST	55	5	55	5
BALTIMORE AV 47TH ST	39	3	39	3
BALTIMORE AV 46TH ST	18	6	18	6
BALTIMORE AV 45TH ST	28	2	29	2
BALTIMORE AV 44TH ST	13	0	0	0
BALTIMORE AV 43RD ST	19	5	42	7
BALTIMORE AV 42ND ST	11	2	0	0
BALTIMORE AV 41ST ST	2	1	0	0
BALTIMORE AV 40TH ST	20	66	22	67

Source: SEPTA, 2014; DVRPC, 2015

To simulate the effects of stop consolidation, select locations were eliminated and their riders redistributed to nearby stops, based on the assumption that a disproportionate number would prefer to board downstream rather than backtrack. **These locations were selected for purposes of simulation only. SEPTA has not yet determined whether to pursue stop consolidation on Route 34, nor has it decided which stops it would prefer to remove through consolidation.**

In order to simulate the effect of two-channel and low-friction boarding, the board times were modified from the original 5 seconds to 2.1 seconds—as per the 59 percent time savings detailed in the "Memorandum on Running Time Savings, as Transmitted" (August 2014; Appendix A). Alight times were modified from 1.9 seconds to 1.4 seconds on the assumption that additional channel capacity may be available for alighting. The effect would be much smaller for alighting since the existing Kawasaki vehicles already have two-channel alighting in practice.

Table C-3 is a summary of network-level indicators for each of the scenarios simulated for this study. The values are averages of the outputs from each of the six simulation runs completed for each of the alternatives.

Table C-3: Summary of Raw Output and All Performance Measures

Alternative	Base	A - 1	A - 2	A - 3	B - 1	B - 2	B - 3
Average End-to-End Time in Minutes (Eastbound)	16.17	16.23	15.87	14.59	14.08	13.73	12.98
Average End-to-End Time in Minutes (Westbound)	13.63	13.79	12.54	12.04	12.57	11.88	11.62
Average Delay Time per Vehicle [sec], All Vehicle Types	46.22	46.50	44.99	41.46	42.53	40.95	39.73
Average Number of Stops per Vehicle, All Vehicle Types	2.01	2.02	1.94	1.81	1.92	1.81	1.76
Average Speed [mph], All Vehicle Types	11.13	11.09	11.27	11.72	11.64	11.85	12.02
Average Stopped Delay per Vehicle [sec], All Vehicle Types	24.86	25.03	24.10	22.12	22.24	21.36	20.94
Total Delay Time [hour], All Vehicle Types	75.78	76.27	73.74	67.89	69.65	67.10	65.04
Total Distance Traveled [miles], All Vehicle Types	1,722	1,721	1,721	1,723	1,720	1,721	1,721
Latent Delay Time [hour], All Vehicle Types *	0.19	0.22	0.29	0.10	0.11	0.15	0.13
Latent Demand, All Vehicle Types **	0.33	0.00	1.00	0.00	0.00	0.67	0.83
Number of Stops, All Vehicle Types	11,835	11,921	11,449	10,676	11,294	10,692	10,381
Number of Vehicles in the Network, All Vehicle Types ***	150.50	156.00	157.00	143.00	144.83	144.67	139.17
Number of Vehicles That Have Left the Network, All Vehicle Types	5,750	5,747	5,742	5,751	5,749	5,752	5,752
Total Stopped Delay [hour], All Vehicle Types	40.76	41.05	39.50	36.22	36.41	35.00	34.28
Total Travel Time [hour], All Vehicle Types	154.81	155.33	152.73	146.94	147.86	145.30	143.27

Source: DVRPC, 2015

*Latent Delay: Wait time for vehicles that were not able to enter the network at their original start time.

**Latent Demand: Vehicles that have not been able to enter the network at the end of the simulation period.

***Number of Vehicles in the Network: Number of active vehicles in the network at end of simulation period.

Analysis of Modernization Scenarios for SEPTA Route 34

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Geographic Area Covered:
City of Philadelphia

Key Words:
SEPTA, Trolley, Wheelchair, ADA, Modernization, Stop Consolidation, Low Friction Fare Payment, Transit Signal Priority, TSP, VISSIM, Microsimulation

Abstract:
This project used microsimulation software to test the travel time and delay outcomes of various trolley modernization scenarios for the street-running portions of SEPTA Route 34. The microsimulation analysis was built on a prior DVRPC Transit First analysis of Route 34 (pub. 09040, March 2010), updated to reflect new 2014 baseline traffic and transit conditions. This effort also included an initial analysis of some of the elements under consideration, drawing on SEPTA data and industry peer experience, as well as sketch projections of likely wheelchair boarding rates for accessible trolleys based on SEPTA's experience with other accessible routes. In general, higher levels of intervention resulted in higher levels of projected cumulative travel time benefit.

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